

OSD RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

February 2008

APPROPRIATION/ BUDGET ACTIVITY
RDTE, Defense Wide BA 03

PE NUMBER AND TITLE
0603711D8Z - Joint Robotics Program/Autonomous Systems

COST (\$ in Millions)	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
P710 Joint Robotics Program/Autonomous Systems	8.765	19.585	8.449	9.276	10.435	11.634	11.974

A. Mission Description and Budget Item Justification: (U) This program element (PE) supports the advanced technology development activities of the Joint Ground Robotics Enterprise (JGRE) with a focus on the development of subsystems and components and efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in simulated environments. Projects deliver advanced technology with direct relevance to enhancing warfighters' capabilities that have been identified during operational assessments and field feedback of current unmanned systems. The PE enables Joint Service coordination and provides for interoperability and commonality among unmanned systems. The primary purpose of this PE is to support efforts to overcome technology barriers in the thrust areas of unmanned ground system technologies to include Autonomous & Tactical Behaviors, Manipulation Technologies, Collaborative Operations, Interoperability, Man-portable Unmanned Ground Systems, and Technology Transition/Transformation. The technologies in the PE are generally at Technology Readiness Levels (TRL) of 4, 5, or 6 making transition and transformation activities critical to closing the requirement to capability gap.

All actions under this PE are within BA 3 and are identified with one project number.

<u>B. Program Change Summary</u>	FY 2007	FY 2008	FY 2009
Previous President's Budget (FY 2008)	8.775	11.256	14.202
Current BES/President's Budget (FY 2009)	8.765	19.585	8.449
Total Adjustments	-0.010	8.329	-5.753
Congressional Program Reductions		-0.171	
Congressional Rescissions			
Congressional Increases			
Reprogrammings		8.500	
SBIR/STTR Transfer	-0.010		
Other			-5.753

<u>C. Other Program Funding Summary</u>	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
PE 0603709D8Z (BA4) Joint Robotics Program	22.975	23.654	11.847	12.005	12.268	12.589	12.916
PE 0604709D8Z (BA5) Joint Robotics Program	9.721	6.851	5.725	5.212	4.245	3.242	3.111

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Comment:

D. Acquisition Strategy Not applicable for this item.

E. Performance Metrics:

FY	Strategic Goals Supported	Existing Baseline	Planned Performance Improvement / Requirement Goal	Actual Performance Improvement	Planned Performance Metric / Methods of Measurement	Actual Performance Metric / Methods of Measurement
07						
08						

Comment: Metrics for the Joint Ground Robotics Enterprise (JGRE) funded RDT&E are articulated in individual project plans and overview quad charts used to form the basis of funding justification and program assessment. These decisions are supported by the JGRE Technology Advisory Board (TAB). The TAB provides technology to capability matrix assessments to inform funding decisions, provide inputs to unmanned system (UMS) roadmaps and ensure technology transitions. In all document sets, project descriptions include task schedules with associated milestones, against which progress toward end goals can be measured. At the level of the performer, efforts are tracked using project technical and management milestones that have been appropriately defined and agreed upon in the project plans. At the enterprise level, the JGRE management structure and process tracks deliverables and examines the transition of technologies and ideas from the performer to DoD programs. The JGRE management structure and process includes a mid-year in progress review (IPR), annual funding justification and prioritization, technology assessments, an O-6 Council and a Senior Steering Group (SSG) overview. These DoD participant reviews include cost, schedule and technical progress assessment against the project milestones. Metric evaluations for the funded actions include, where appropriate, controlled trials, demonstrations, quasi-experimental evaluations, and direct/indirect analysis.

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B. Accomplishments/Planned Program:

<u>Accomplishments/Planned Program Title:</u>	<u>FY 2007</u>	<u>FY 2008</u>	<u>FY 2009</u>
(U) Autonomous & Tactical Behaviors	1.268	5.470	1.200

FY2007 Accomplishments:

- * Virtual Autonomous Navigation Environment (VANE) - Identified the necessary tasks, best modeling architecture and architecture development process for the VANE vehicle dynamic's and graphic's software and Joint Architecture for Unmanned Systems (JAUS) compliant VANE vehicle dynamics software.
- * Developed and implemented 70% of the research plan for best modeling architecture and architecture development process for the VANE vehicle dynamic's and (JAUS) compliant VANE vehicle dynamics software.
- * Initiated evaluation of Software Integration Lab (SIL) connection to the VANE.
- * Demonstrated deliberative and obstacle avoidance for unmanned surface vehicles used digital nautical charts, marine radar and AIS sensor fusion
- * Tested stereovision sensor system for on-the-water obstacle detection
- * Developed detection and exploration behavior for enhanced autonomous navigation and more efficient search patterns in urban environments
- * Demonstrated human presence detection based on fused thermal and color cameras, and investigated performance when integrated with navigation and change-detection behaviors
- * Developed generic framework for evaluation of varying classifiers for object detection/recognition of tactical objects
- * Demonstrated autonomous mobility, manipulation, and novel human/robot interfaces to the EOD user community.
- * Transitioned unmanned vehicle technologies from unmanned ground vehicles to unmanned surface vehicles to rapidly increase USV autonomous navigation software development.

FY 2008/2009 Plans: Support the development of vehicle onboard intelligence and tactical behaviors to allow the fielding of advanced autonomous unmanned systems. Baseline user identified

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mission scenarios to develop operational behaviors enabling unmanned operations within the conduct of mission tasks. Increase the warfighter's capability by transferring and developing technologies that will have an immediate impact on the autonomy and functional capabilities of current and future robotic systems. Enable transitioning of technologies appropriate for small robots from the technology transfer program to fielded systems. Plans include:

- * Autonomous Navigation for Small UGVs - Develop, test, and prototype navigation sensors and software designed specifically for small UGVs to enable autonomous navigation.
- * Computer Assisted Robotic Manipulation (CARMAN)
- * Urban Environment Exploration and Modeling - Enable robotic platforms to more effectively operate within the challenging conditions of dynamic urban environments; demonstrate autonomous generation of a 3-D model of urban structures; UGV mission planning and coordination.
- * Autonomous Control Development - Mission planning and execution capabilities.
- * Computer Assisted Tele-Operation (CATO)
- * Explosive Ordnance Disposal (EOD) Cooperative Robotics
- * Advanced EOD Robot System Technology Development - Mature and reduce risk (to TRL 6) of specific autonomous navigation, autonomous manipulation, dexterous manipulation, and scalable mobility technologies
- * Autonomous & Semi-Autonomous Manipulation for Ground Robotics
- * Warrior Unmanned Ground Vehicle

<u>Accomplishments/Planned Program Title:</u>	<u>FY 2007</u>	<u>FY 2008</u>	<u>FY 2009</u>
(U) Collaborative Operations	1.305	3.257	2.255

FY2007 Accomplishments:

- * Optimized a 3-D augmented virtuality interface for multiple robot control
- * Evaluated various speech recognition engines for multi-modal robot control interfaces
- * Implementation of demonstrations of realistic autonomous capabilities to EOD users

FY 2008/2009 Plans: Integrate communication, mission planning, interface technologies, and advanced intelligence capabilities to support collaborative operations between manned and unmanned systems. Develop and assess several strategies to enhance tele-operation of current UGVs and collaborative UAV teams. Collaborative and tactical behaviors include system convoying, teamed obstacle avoidance, area perception and relative position information sharing. Plans include:

- * Man-Portable Robotic Systems (MPRS)
- * Computer Assisted Tele-Operation (CATO)- Improve Tele-Operated Mobility , Performance and Assess Operational Effectiveness
- * Collaborative Engagement Experimentation
- * Convoy Active Safety Technologies (CAST)
- * EOD Cooperative Robotics - Develop a plan to transition Cooperative Robotics technologies to other EOD Robotics projects or acquisition programs.

<u>Accomplishments/Planned Program Title:</u>	<u>FY 2007</u>	<u>FY 2008</u>	<u>FY 2009</u>
(U) Interoperability	1.072	1.992	0.852

FY 2007 Accomplishments:

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- * Under Man-Portable Robotic Systems (MPRS) projects, completed transition to fully Joint Architecture for Unmanned Systems (JAUS) Level 2 software architecture for small UGV semi-autonomous navigation.
- * Developed new JAUS components to enable USV path planning and reactive obstacle avoidance within the JAUS architecture
- * Expanded generic behavior architecture from Idaho National Laboratory (Autonomous UAV Mission System [AUMS]) to include generic classes of perceptions, mission payloads, behaviors, and communication protocols (JAUS included)
- * Optimized a navigation package consisting of obstacle avoidance, mapping and path planning, GPS waypoint following, adaptive localization, and seamless indoor/outdoor navigation and enhanced dead reckoning.

FY 2008/2009 Plans: Promote and guide technology development to meet joint requirements and promote ground as well as air unmanned systems interoperability. Support the bridging of currently incompatible robots and controllers from various manufacturers, using different communications channels and hardware. Optimize best features of prior/ongoing research efforts into a maturing, standardized system that can be easily ported to robotic platforms used DoD-wide. Plans include:

- * Rapid Prototyping & Integration of Robotic Systems - A systems engineering approach to the design and implementation of software for prototyping robotic systems.
- * Robotic Systems Technical & Operational Metrics Correlation
- * Joint Collaborative Technologies Experiment (JCTE)

Accomplishments/Planned Program Title:

FY 2007

FY 2008

FY 2009

(U) Man-Portable Unmanned Ground System Technologies

1.448

1.661

1.352

FY 2007 Accomplishments:

- * Virtual Autonomous Navigation Environment (VANE) - Identified the necessary tasks, best modeling architecture and architecture development process for the VANE vehicle dynamic's and graphic's software and Joint Architecture for Unmanned Systems (JAUS) compliant VANE vehicle dynamics software.
- * Under VANE, initiated evaluation of Software Integration Lab (SIL) connection to the VANE.
- * Demonstrated stereovision based obstacle avoidance and guarded teleoperation under Man-Portable Robotic Systems (MPRS) projects.
- * Initiated improvement program for integration of UGV in combat.
- * Completed transition to fully JAUS Level 2 software architecture for small UGV semi-autonomous navigation.

FY 2008/2009 Plans: Increase the warfighter's capability by transferring and developing technologies that will have an immediate impact on the functional capabilities of man-portable robotic systems. Enable transitioning of technologies appropriate for small robots from the technology transfer program to fielded systems. Included: Support to the identification of a M & S architecture and specifications with EOD robot specific mission-application. Specific technologies include obstacle detection/obstacle avoidance (ODOA) and collaborative behaviors for small vehicles. Plans include:

- * Low-Cost UGV for IED Neutralization
- * Man-Portable Robotic Systems (MPRS)
- * EOD Cooperative Robotics
- * Urban Environment Exploration and Modeling - Demonstrate and establish metrics for dynamic localization techniques, large-scale, complex terrain and obstacle avoidance, and reactive, real-time path planning in the presence of moving obstacles.

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<u>Accomplishments/Planned Program Title:</u>	<u>FY 2007</u>	<u>FY 2008</u>	<u>FY 2009</u>	
(U) Technology Transition/Transformation	2.082	3.974	1.085	
<p>FY2007 Accomplishments:</p> <ul style="list-style-type: none"> * Transitioned unmanned vehicle technologies from unmanned ground vehicles to unmanned surface vehicles to rapidly increase USV autonomous navigation software development. * Demonstrated deliberative and obstacle avoidance for unmanned surface vehicles used digital nautical charts, marine radar and AIS sensor fusion. * Demonstrated robotic search behaviors with a radiological sensor. * Tested stereovision sensor system for on-the-water obstacle detection. * Demonstrated stereovision based obstacle avoidance and guarded teleoperation. * Ported integration navigation package consisting of obstacle avoidance, mapping and path planning, GPS waypoint following, adaptive localization, and seamless indoor/outdoor navigation, enhanced dead reckoning, and 3-D visualization tools to a ruggedized payload on an iRobot PackBot for user evaluation in a relevant environment. * Evaluated and integrated robotic search behavior with radiological sensor from industry, SpaceMicro. * From industry evaluated an acoustic sensor into a detection system, AETC; a video contrast enhancement module, DigiVision, on iRobot PackBot; leave behind sensors, CornerTurn. * Optimized a navigation package consisting of obstacle avoidance, mapping and path planning, GPS waypoint following, adaptive localization, and seamless indoor/outdoor navigation and enhanced dead reckoning. <p>FY 2008/2009 Plans: Facilitate integration of and ensure the ultimate transfer or transformation of technologies to ongoing programs. Exploit the best features of past and on-going efforts while supporting the development of technologies that have low risk to transition. Technologies of interest include: Interface Technologies (Human Robot Interaction), Autonomous Operations (Information Fusion, Perception, and Navigation), Autonomous Technologies (Positioning), and Platform Technologies. Plans include:</p> <ul style="list-style-type: none"> * Pursuing noise suppression technologies for robotic stealth operations & survivability. * Modeling and Simulation for EOD Robot Tactics Development * Identifying a M&S architecture for the development of EOD robot specific mission-application. * Developing and employing of a medium fidelity analytic modeling and simulation (M&S) capability for EOD Robot Tactics Development. * EOD Cooperative Robotics - transition Cooperative Robotics technologies to other EOD Robotics projects or acquisition programs. * Autonomous & Semi-Autonomous Manipulation for Ground Robotics * Legged Robotics * Warrior Unmanned Ground Vehicle 				
<u>Accomplishments/Planned Program Title:</u>	<u>FY 2007</u>	<u>FY 2008</u>	<u>FY 2009</u>	
(U) Manipulation Technologies	1.590	3.231	1.705	
<p>FY2007 Accomplishments:</p> <ul style="list-style-type: none"> * Initiated improvement program for integration of UGV in combat. * Initiated engineering change proposals (ECP)for manipulator technologies. * MTRS manipulator strengthening. 				

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FY 2008/2009 Plans: Incorporate existing technologies into systems representative to those in use, demonstrate ease of robotic manipulation, support the development of mobile manipulation, expedite the transition and integration of corresponding robotic technologies to enhance the current fielded systems with more functionalities, autonomy and state-of-the-art behavior with interface methods from the RTD&E environment. Plans include:

- * Advanced EOD Robot System Technology Development - Mature and reduce risk (to TRL 6) of specific autonomous navigation, autonomous manipulation, dexterous manipulation, and scalable mobility technologies
- * Pursue noise suppression technologies for robotic stealth operations & survivability.
- * Urban Environment Modeling - autonomous generation of a 3-D model of urban structures and use of 3-D models for UGV mission planning and coordination.
- * Autonomous & Semi-Autonomous Manipulation for Ground Robotics
- * Autonomous Control Development
- * Legged Robotics
- * Warrior Unmanned Ground Vehicle

<u>C. Other Program Funding Summary</u>	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
PE 0603709D8Z Joint Robotics Program (BA4)	22.975	23.654	11.847	12.005	12.268	12.589	12.916
PE 0604709D8Z Joint Robotics Program (BA5)	9.721	6.851	5.725	5.212	4.245	3.242	3.111

Comment:

D. Acquisition Strategy The Joint Ground Robotics Enterprise (JGRE) utilizes several contracting and management strategies to achieve its objectives. JGR has established relationships with the several agencies to include the National Center for Defense Robotics (NCDR) and the Army's Rapid Equipping Force (REF) to support the rapid acquisition and evaluation of promising unmanned system technologies.

Funding is provided to Service lab partners and other developers to promote common technology solutions across platforms and Services.

Beginning in FY08, JGRE will encourage the establishment of a robotics consortium to broaden the research and development of robotics technologies.

E. Major Performers Not applicable for this item.